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GEOHYDROLOGY AND GROUND WATER
POTENTIAL OF
ST. JOSEPH COUNTY, INDIANA



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GEOHYDROLOGY AND GROUND-WATER POTENTIAL OF

ST. JOSEPH COUNTY, INDIANA

By J. D. Hunn and J. S. Rosenshein

ABSTRACT

The principal sources of ground water in St. Joseph County are the unconsolidated rocks of Quaternary age. These rocks form a single but complex hydrologic system that is locally more than 450 feet thick and consists of three units. These units were previously recognized in Lake, Porter and La Porte Counties, where they were designated as units 2, 3 and 4, in descending order. Unit 1 is missing in St. Joseph County. The ground-water potential of the county is estimated to be 400 mgd (million gallons per day) of which about 54 mgd is being pumped.

Unit 4 consists of clay till containing discontinuous zones of sand and gravel, which are potential sources of moderate to large supplies of water. Sand and gravel within unit 4 is the principal aquifer in the South Bend-Mishawaka area, yielding as much as 3,000 gpm (gallons per minute) to individual wells.

Unit 3, a sand and gravel, is the principal aquifer of the county. This unit is partly artesian and partly water-table. Recharge is derived chiefly from local precipitation. Recharge to the artesian part and to about 70 square miles of the water-table part of the aquifer must percolate through the overlying till (unit 2). This recharge is estimated to average 200,000 gpd (gallons per day) per square mile, or about 40 mgd. Recharge to that part of the aquifer which is exposed at the surface is estimated to average 1.2 mgd per square mile. The potential yield from natural recharge of this part of the aquifer is estimated to be 350 mgd. Possible yields to individual wells range from about 25 to more than 3,000 gpm. Pumpage from the unit is about 32 mgd, or about 69 percent of the ground water pumped in the county.

Unit 2, a silt till, is the confining layer for the artesian part of the principal aquifer. The unit may have as much as 2 million acre-feet of water in storage. Production from the unit is limited to relatively thin, discontinuous sand and gravel zones and is not a significant part of the ground water pumped in the county.

INTRODUCTION

Purpose and Scope

A ground-water investigation is currently being conducted in northwestern Indiana by the U. S. Geological Survey, in cooperation with the Division of Water, Indiana Department of Natural Resources, as part of the statewide investigation of ground-water resources in Indiana. The purpose of this report is to describe the geologic and hydrologic characteristics of the aquifers, to estimate their current and potential yields, and to identify the problems relating to their development. This is the third and last of a series of interpretive reports scheduled for the area. It presents an evaluation of the ground-water resources of St. Joseph County (fig. 1) and provides information to guide the development and management of these resources.

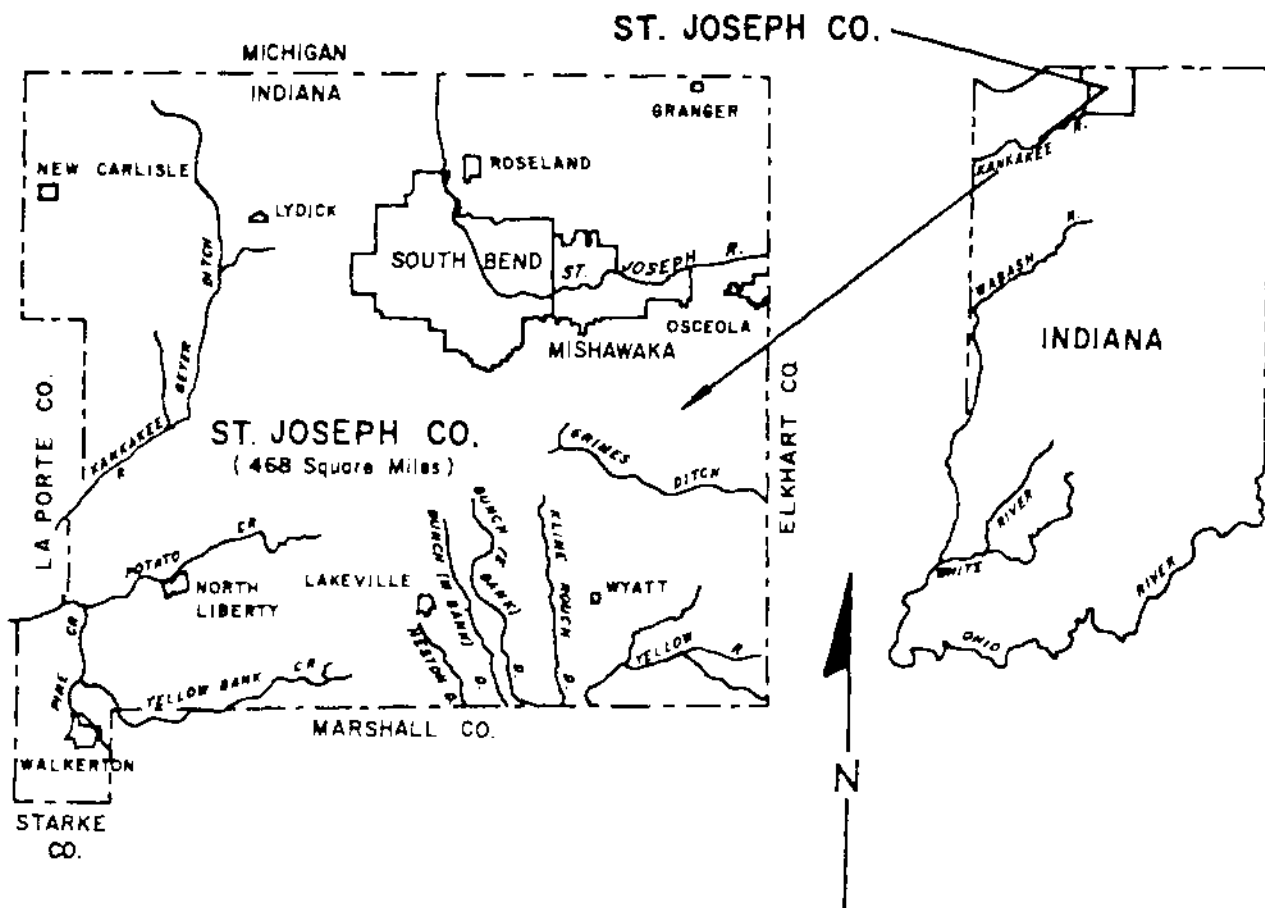


FIGURE 1.--Map of Indiana showing area covered by this report.

The demand for water will increase during the next few decades, as a result of the economic development of the Great Lakes region, and the available ground water in the county will be a source of supply of increasing importance.

Although the available ground water should be more than adequate to satisfy the needs of the county for several decades, the increased demands will produce hydrologic problems such as those of contamination and well spacing which are common to highly urbanized areas. Therefore, in order to tap a major part of the potential yield, sound practices of development and responsible management of water resources will be required.

Previous Investigations

A detailed evaluation of the ground-water resources of St. Joseph County has not previously been published; however, Klaer and Stallman (1948) prepared a quantitative evaluation of the ground-water resources of the South Bend area. The water-bearing sand and gravel described by them is separated into two units (3 and 4) in the present report. A preliminary evaluation of the ground-water resources of the county is published in a report by Rosenshein and Hunn (1963a). Other publications referring to St. Joseph County are listed in the "Selected References," at the end of this report.

Acknowledgments

The authors thank all persons who contributed time, information, and assistance during the preparation of this report. The investigation was under the immediate supervision of C. M. Roberts, district geologist of the Ground Water Branch, U. S. Geological Survey. R. J. Vig, formerly of the U. S. Geological Survey, assisted in the geologic reconnaissance and data processing. Well drillers supplied logs and other information. A. F. Schneider, of the Geological Survey, Indiana Department of Natural Resources, permitted use of his interpretation of a soil map of St. Joseph County (Ulrich and others, 1950).

The following government agencies provided information: the Geological Survey, the Division of Oil and Gas, and the Division of Water, all in the Indiana Department of Natural Resources; the Indiana State Highway Department; the Indiana Toll Road Commission; and the Indiana State Board of Health.

CLIMATE AND GEOGRAPHY

The average annual precipitation at South Bend, the county seat, is about 37 inches, and the average annual air temperature is about 49° F.

The Maxinkuckee moraine, extending from South Bend southward into Marshall County, is the chief topographic feature of the area. A drainage divide extends from northwest to southeast across the county and separates the St. Lawrence River basin from the Mississippi River basin.

The maps in this report show the pattern of the principal streams and ditches. Points of highest elevation are on the Maxinkuckee moraine, and the lowest elevation in the county is the surface of the St. Joseph River where it enters Michigan; maximum relief is about 260 feet.

GEOHYDROLOGY OF THE PRINCIPAL WATER-BEARING UNITS

General Aspects

The principal sources of ground water in St. Joseph County are the unconsolidated rocks, which locally are more than 450 feet thick and were deposited chiefly as a result of glaciation during Pleistocene time. These rocks form a single but complex hydrologic system from which about 54 mgd (million gallons a day) of water is currently being withdrawn.

Rosenshein (1962) subdivided the rocks into the lithologic units used in this report. The units are discussed in ascending order. Their stratigraphy, character and distribution, and geohydrologic properties are summarized in table 1. The areal extent of those units that are exposed at the surface is shown on plate 1.

The underlying dolomite, dolomitic limestone, and shale of Devonian age are potential sources of water of uncertain quality and quantity, but are not presently used.

Unit 4

Water-Bearing Characteristics

Unit 4 is a clay till that contains zones of sand and gravel which are generally discontinuous and small in areal extent. The unit underlies about 90 percent of the county and is as much as 350 feet thick in buried valleys. It is not exposed at the surface. The vertical permeability (see p. 17) of the till is probably similar to that estimated by Rosenshein (1963) for the part of the same unit underlying Lake County-- 0.003 gpd (gallons per day) per square foot. The porosity (p. 18) of the till may be as much as 30 to 40 percent (Rosenshein and Hunn, 1968a, p.21) and the unit may have as much as 6 million acre-feet of water in storage.

Quality of Water

Water in unit 4 is chemically similar to water in the overlying aquifer, unit 3 (p. 7). However, the water in unit 4 is more uniform in quality, and may represent a mixing of recharge water from unit 3 containing wider ranges of dissolved constituents. The quality of water in unit 4 is summarized in table 2, and the significance of the dissolved constituents is shown in table 3.

Table 1. Stratigraphic section and summary of water-bearing properties of rocks of Quaternary age, St. Joseph County, Indiana

System	Series	Stratigraphic unit	Thickness (feet)		Character and distribution	Geohydrologic properties and significance	Remarks
			Range	Average			
Quaternary	Recent and Pleistocene	Unit 2	0-140	50	Till, silt, sandy and somewhat clayey; moderately calcareous, pebbly and cobbly; generally yellowish-gray to brown; contains discontinuous lenses of sand and gravel of small areal extent; underlies about 181 square miles of the county.	Discontinuous sand and gravel lenses utilized locally as a source of water for some domestic and farm supplies; mantle artesian and water-table parts of unit 3; contributes to base flow of streams.	Forms dissected ground and terraced surfaces.
		Unit 3	70-380	120	Sand, generally medium to coarse, somewhat pebbly, silty and clayey, calcareous, and sand and gravel; grains subrounded to rounded, composed of fragments of shale, quartz, dolomite, limestone, and igneous and metamorphic rocks; locally contains thick clays of small areal extent; underlies the entire county.	Principal aquifer, potential source of water supplies of less than 10 to more than 1,000 gpm; contributed to base flow of streams. Estimated average permeability, 900 gpd per square foot. Estimated average coefficient of storage, 0.003 for artesian part, 0.12 for water table part.	
		Unit 4	0-300+	80	Till, clay, silty, sandy, pebbly, slightly to moderately calcareous, locally hard and compact, olive-gray to greenish gray, contains discontinuous sand and gravel lenses; underlies about 420 square miles of the county.	Sand and gravel zones utilized locally as source of water for some municipal and industrial supplies, and occasionally for domestic and farm supplies. Yields as much as 1,000 to more than 3,000 gpm to individual wells in the South Bend area.	

Development and Potential

The sand and gravel zones within unit 4 are used locally throughout the county as a source of water for municipal and industrial supplies and occasionally for domestic and farm use. These zones are tapped either in a search for large supplies of water or to obtain supplies free of contamination. In most of St. Joseph County larger yields are possible in unit 3, the sand and gravel aquifer overlying unit 4. Wells tapping unit 4 discharge an estimated 22 mgd, or about 41 percent of the ground water used in the county. Of this amount about 14.8 mgd is pumped for municipal use by South Bend, Mishawaka, New Carlisle, and Walkerton, and about 7 mgd for industrial and commercial use.

Table 2.--Summary of water quality in unit 4.

Constituent or property	Minimum (ppm)	Maximum (ppm)	Mode (most common value) (ppm)	Average	Number of samples
Iron (Fe)	< 0.1	2.5	0.14	1.04	47
Bicarbonate (HCO ₃)	151	549	295	312	48
Sulfate (SO ₄)	< 5	260	-----	75	18
Chloride (Cl)	< 4	108	14	16	47
Hardness as CaCO ₃	128	508	279	300	48
Total dissolved solids	267	649	-----	397	16

Sand and gravel within unit 4 is the principal aquifer in the South Bend-Mishawaka area. Klaer and Stallman (1948, pls. 4 and 5) refer to this aquifer as the "deeper sands and gravels." The transmissibility (p. 17) of this aquifer ranges from less than 10,000 to more than 300,000 gpd per foot. The permeability ranges from less than 200 to more than 6,000 gpd per square foot. The average coefficient of storage was calculated by Klaer and Stallman (1948) to be 3×10^{-4} . Figure 2 shows estimated transmissibilities and relates these to specific capacities (p. 18) and possible yields obtainable from properly constructed wells. The specific capacities are those to be expected for a 12-inch well after pumping for 1 day. The yield for a specified drawdown will be greater for a large-diameter well than for a small-diameter well. Owing to these and other factors, such as well efficiency, figure 2 gives

only an approximation of the capability of the aquifer as a source of water.

Much of this aquifer is a possible source of water for users requiring 1,000 gpm or more. However, actual yields from improperly constructed wells may be considerably less than those indicated on figure 2. Proper construction requires careful choice of well diameter, screen diameter and length, and slot size of screen openings. Guidelines to aid in proper selection of the above factors are given by Walton (1962, p. 28-30). Wells tapping unit 4 require development to remove the clay, silt, and very fine sand from the immediate vicinity of the screen.

The depth to the water-bearing zone can be estimated from figure 3. This information may then be used in conjunction with information on figure 2 to estimate the depth to which a well must be drilled in order to develop a water supply. For maximum yield, the full thickness of the aquifer should be screened.

Klaer and Stallman (1948, p. 43) reported that water levels in the South Bend-Mishawaka area declined at an average rate of 0.5 foot per year for the period 1895-1945. This rate of decline includes both unit 4 and unit 3 (p. 7). Available observation-well records indicate that water levels in both units have declined at an average rate not greater than 0.2 foot per year from 1946 to the present time. The long-term decline of water levels does not indicate a present or a future water shortage. The hydrograph of well St. Joseph 17 on figure 4 illustrates the maximum recorded long-term decline of water levels in unit 4 since 1946. This hydrograph also shows the effects of seasonal variations of recharge and discharge, and of pumping of nearby wells.

Transmissibilities of sand and gravel zones outside the South Bend area range from about 1,000 to about 10,000 gpd per foot. The permeability ranges from less than 100 to about 800 gpd per square foot. The potential of most of these zones for development is limited by their small areal extent and by the small vertical permeability of the enclosing till, which largely determines the rate of recharge. Recharge is derived chiefly from local precipitation percolating downward through the overlying units.

Unit 3

Water-Bearing Characteristics

Unit 3 consists chiefly of sand and gravel that locally contains thick zones of clay. This unit underlies the entire county and is the principal aquifer. It is overlain by till (unit 2, p. 16) in the southeastern part and in a small area in the northwest corner of the county (pl. 1). The aquifer is water-table, except in about half the area overlain by unit 2 in the southeastern part of the county.

The permeability of unit 3 ranges from less than 100 to more than 5,000 gpd per square foot. The coefficient of transmissibility ranges

Table 3.--Significance of selected dissolved mineral constituents and properties of ground water^{a/}

Constituent or property	Significance
Iron (Fe)-----	Oxidizes to reddish-brown sediment upon exposure to air. More than about 0.3 ppm stains laundry and utensils reddish-brown. More than 0.5 to 1.0 ppm imparts objectionable taste to water. Larger quantities favor growth of iron bacteria. Objectionable for food processing, textile processing, beverages, ice manufacturing, brewing, and other purposes.
Calcium (Ca) and Magnesium (Mg)-----	Cause most of the hardness and scale-forming properties of water; soap consuming. See hardness. Waters low in calcium and magnesium desired in electroplating, tanning, dyeing, and in textile manufacturing.
Sodium (Na) and Potassium (K)-----	Large amounts, in combination with chloride, give a salty taste. Moderate quantities have little effect on the usefulness of water for most purposes. Sodium salts may cause foaming in steam boilers and a high sodium ratio may limit the use of water for irrigation.
Bicarbonate (HCO ₃)-----	Bicarbonate in conjunction with carbonate (CO ₃) produces alkalinity. Bicarbonate of calcium and magnesium decomposes in steam boilers and hot water facilities to form scale and release corrosive carbon-dioxide gas.
Sulfate (SO ₄)-----	Sulfate in water containing calcium forms hard scale in steam boilers. In large amounts sulfate in combination with other ions gives bitter taste to water. Some calcium sulfate is considered beneficial in the brewing process. Public Health Service drinking-water standards ^{b/} recommend that the sulfate content should not exceed 250 ppm.
Chloride (Cl)-----	Gives salty taste to drinking water when present in large amounts in combination with sodium. Increases the corrosiveness of water when present in large amounts. Public Health Service drinking-water standards ^{b/} recommend that the chloride content should not exceed 250 ppm.
Dissolved solids-----	Public Health Service drinking-water standards ^{b/} recommend that the dissolved solids should not exceed 500 ppm. Waters containing more than 1,000 ppm of dissolved solids are unsuitable for many purposes.
Hardness as CaCO ₃ (Calcium and magnesium)-----	Hard water increases amount of soap needed to wash laundry. Forms scale in boilers, water heaters, and pipes. Leaves curdy film on bathtubs and other fixtures and on materials washed in the water.

^{a/} Adapted in part from Palmquist and Hall (1961), p. 34-36.

^{b/} U. S. Public Health Service (1962)

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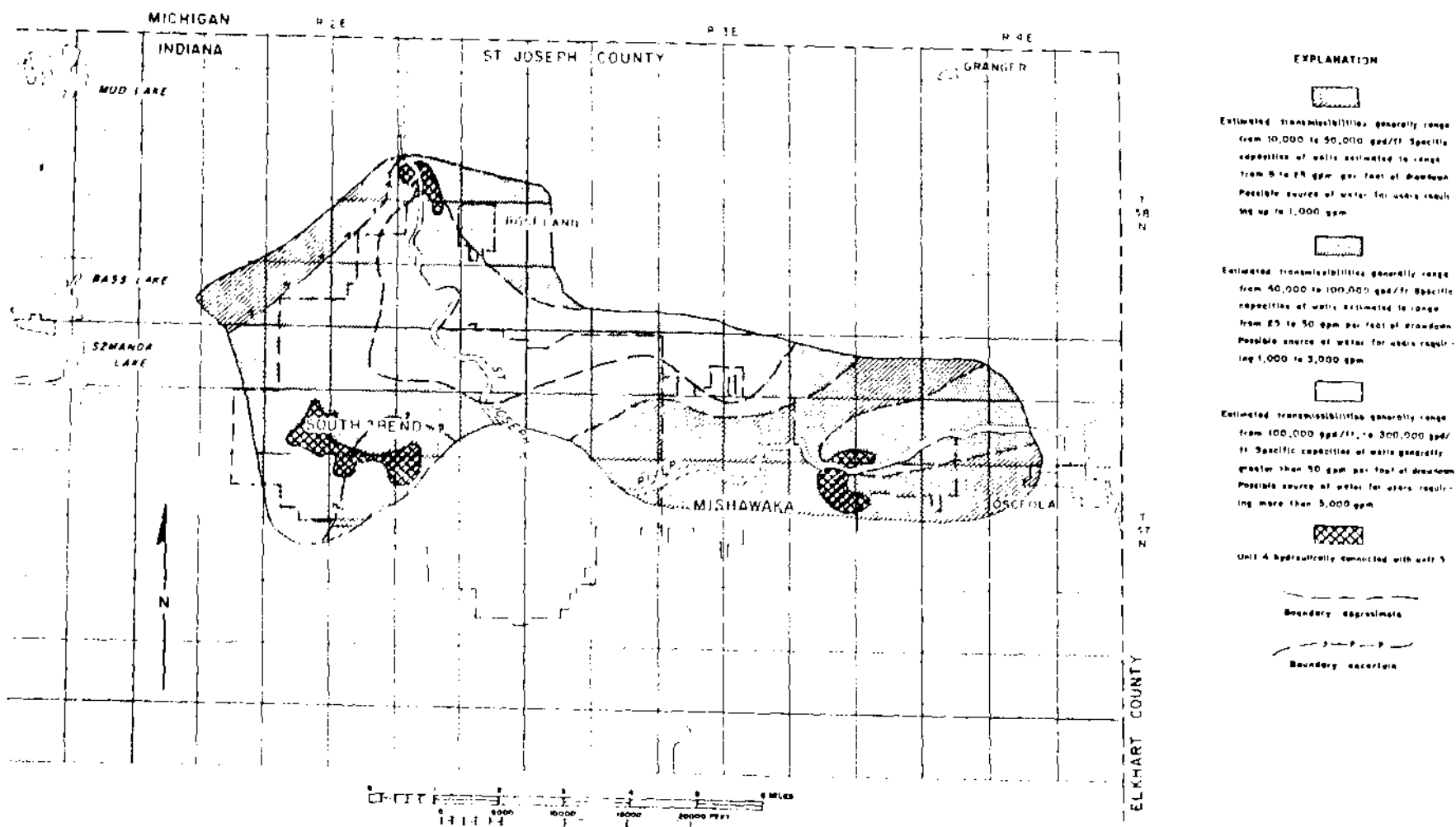


FIGURE 7 -- Map of the South Bend - Mishawaka area, showing capability of unit 4 as a source of water

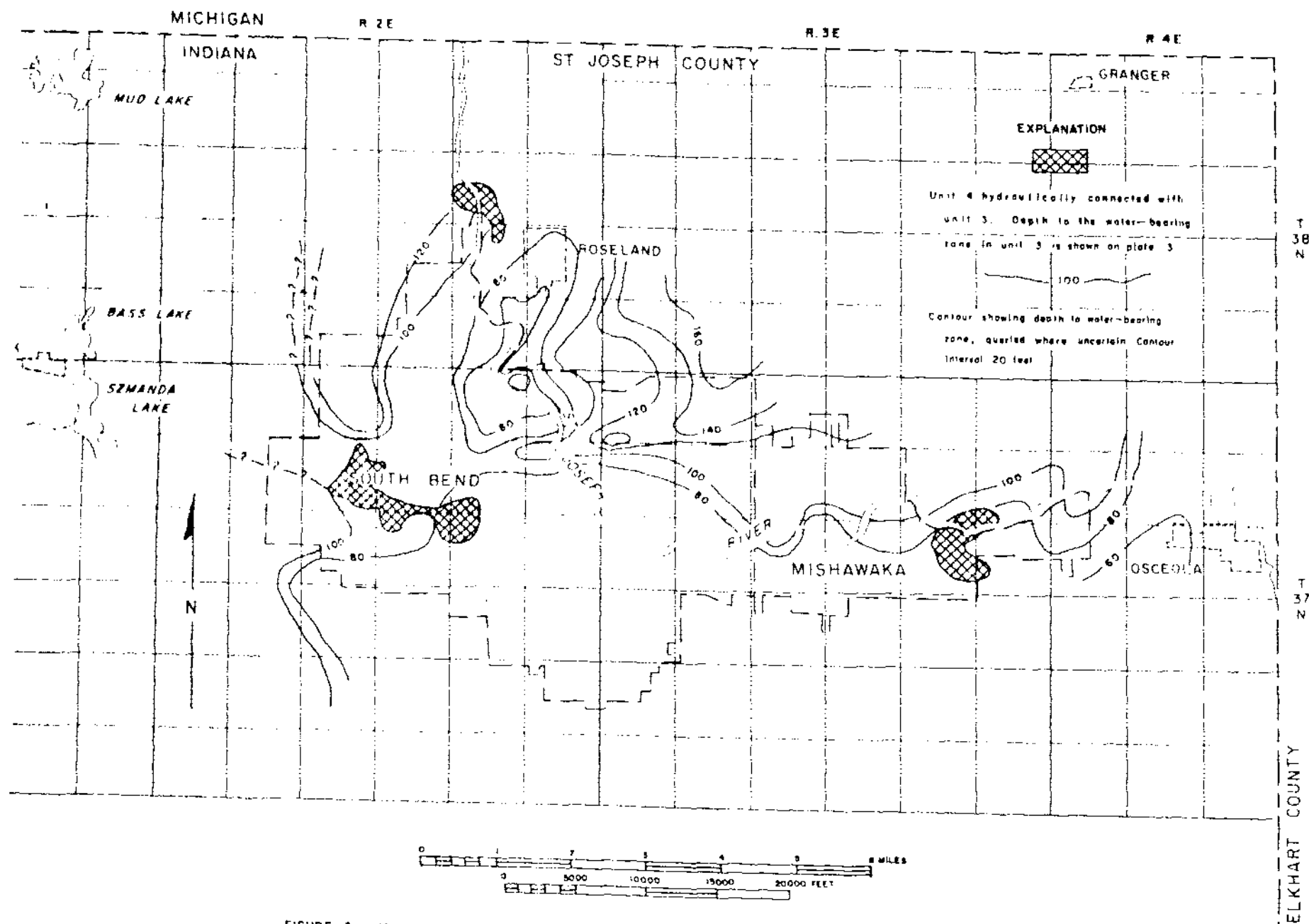


FIGURE 3 - Map of the South Bend-Mishawaka area, showing depth to the water-bearing zone in unit 4

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Geological and geophysical
information and data,
including maps, concerning
wells.

from less than 10,000 up to 500,000 gpd per foot. The unit has an estimated regional transmissibility of 70,000 gpd per foot.

Rosenshein and Hunn (1968a, p. 21) have estimated that in Lake County the coefficient of storage for the artesian part of the aquifer averages 0.003 and for the water-table part 0.12. These estimates should be sufficiently accurate to evaluate regional characteristics of the aquifer in St. Joseph County.

Recharge and Discharge

Fluctuations of the water level in the aquifer due to seasonal variations of recharge and discharge and to pumping of nearby wells are shown on figure 4. This hydrograph also shows the maximum recorded decline of water levels in unit 3 in the South Bend area since 1946.

Recharge to the unit is derived chiefly from precipitation within the county. Some ground water enters the county by underflow from nearby areas in Michigan and in La Porte County, Indiana. During periods of heavy pumping in South Bend, some infiltration is induced from the St. Joseph River.

Recharge to the artesian part of the aquifer, and to much of the water-table part, must take place by slow percolation through the overlying till (unit 2, p. 16). This recharge is estimated to average 200,000 gpd per square mile.

That part of the unit which is exposed at the surface (pl. 1) is recharged mainly by direct percolation of precipitation through the upper part of the unit. This recharge is estimated to average 1.2 mgd per square mile.

Natural discharge from the water-table part occurs chiefly as effluent seepage (p. 17) to the ditches and streams that penetrate the unit and as direct evapotranspiration. Effluent seepage constitutes most of the discharge in the nongrowing season and only a small part in the growing season. The importance of the streams and ditches as a means of discharge from the unit is indicated by their effects upon the configuration of the piezometric surface (fig. 5). This discharge produces most of the streamflow from July through September.

Discharge by evapotranspiration from the water-table part in the growing season occurs chiefly where the water-bearing zone is less than 20 feet below the land surface (pl. 3). Although no detailed evaluation of this discharge has been made, it should be similar per square mile to that estimated for the water-table part of this unit in Lake County (Rosenshein and Hunn, 1968a, p. 24). This discharge in St. Joseph County was probably about 20,000 million gallons or about 130 mgd during the 1960 growing season.

Natural discharge from the artesian part of unit 3 occurs as upward

leakage through the overlying till. Some discharge by evapotranspiration takes place locally where the confining layer is less than 20 feet thick; however, the quantity discharged must be relatively small. Some discharge from both the artesian and the water-table parts occurs also as downward movement to the underlying rock units.

Wells tapping unit 3 discharge an estimated 32 mgd. This discharge accounts for about 59 percent of the ground water used in the county. Of this amount, about 17 mgd is pumped for domestic and farm use, about 11.6 mgd for municipal use by South Bend, Mishawaka, Lakeville, North Liberty, Walkerton and Wedgewood Park, and about 3.7 mgd for industrial and commercial use.

Quality of Water

The principal constituents of the water are bicarbonate, calcium, and magnesium. Locally, sulfate is a major constituent. Concentrations of the dissolved constituents are summarized in table 4. The significance of these constituents is shown in table 3. Maps showing distribution of hardness and iron concentrations in St. Joseph County have been published in a preliminary report (Rosenshein and Hunn, 1963a).

Bicarbonate concentrations in unit 3 are often relatively high where the unit is overlain by unit 2, a calcareous silt till (p. 16). This relationship is not as pronounced in St. Joseph County as in Lake and Porter Counties (Rosenshein and Hunn, 1968a and 1968b), where the till is finer grained, and exposes more surface area per unit volume to percolating ground water.

Table 4.--Summary of water quality in unit 3.

Constituent or property	Minimum (ppm)	Maximum (ppm)	Mode (most common value) (ppm)	Average	Number of samples
Iron (Fe)	< 0.1	7.5	0.12	0.72	368
Bicarbonate (HCO ₃)	24	512	312	306	373
Sulfate (SO ₄)	< 5	430	37	44	210
Chloride (Cl)	< 4	164	12	15	370
Hardness as CaCO ₃	96	816	276	287	372
Total dissolved solids	70	1,010	340	343	206

Development and Potential

Plate 2 shows estimated transmissibilities and relates these to specific capacities and possible yields obtainable from properly constructed wells. The specific capacities are those to be expected for a 12-inch well after pumping for 1 day. The yield for a specified draw-down will be greater for a large-diameter well than for a small-diameter well, and will decrease with time of pumping. Possible yields for the water-table part of the aquifer are estimated from the specific capacities, by using a drawdown limited to one-half the saturated thickness of the unit. Owing to these and other factors, such as well efficiency, plate 2 gives only an approximation of the capability of the aquifer as a source of water. Much of the unit is a possible source of water for users requiring 500 gpm or more. However, without proper construction (see p. 7), actual yields of wells may be considerably less than those indicated on plate 2.

The depth to the water-bearing zone in unit 3 can be estimated from plate 3. This information can then be used in conjunction with plate 2 to estimate the depth to which a well must be drilled to develop an adequate water supply. For maximum yields from the artesian part, the full thickness of the aquifer should be penetrated and screened. For domestic or farm supplies only the upper 10 to 15 feet need be penetrated and a short, small-diameter screen used.

The quantity of water potentially available for development from unit 3 depends on its rate of recharge. In part of the area this rate is controlled to a large extent by the geohydrologic properties of the overlying till, unit 2. Recharge to this part of the aquifer is currently estimated to be 40 mgd. Rosenshein (1963, p. 17) has shown that the rate of recharge to the artesian part will increase as it is extensively developed. This increase could raise the potential of this part of the unit to about 80 mgd.

The potential yield of the water-table part that is exposed at the surface is estimated to be 300 mgd. Development of water supplies in this part is complicated by several factors. The saturated thickness varies seasonally by about 2 to 5 feet. Because pumping from the water-table part results in an actual dewatering of the unit, the transmissibility decreases as water is withdrawn. Estimates of the specific capacities and possible yields of this part of the aquifer (pl. 2) have been adjusted for these factors.

The current pumpage is only about 8 percent of the water potentially available for use from the aquifer.

Land-use practices and the susceptibility of shallow aquifers to contamination also complicate possible development. The land in much of the area is used chiefly for farming. As a result, it is continually being ditched--a practice that decreases the average saturated thickness, thereby permanently dewatering a part of the aquifer and decreasing its potential for development. Because the aquifer is readily susceptible to contamination, the user should guard against waste-disposal methods that permit downward leakage of undesirable waste products.

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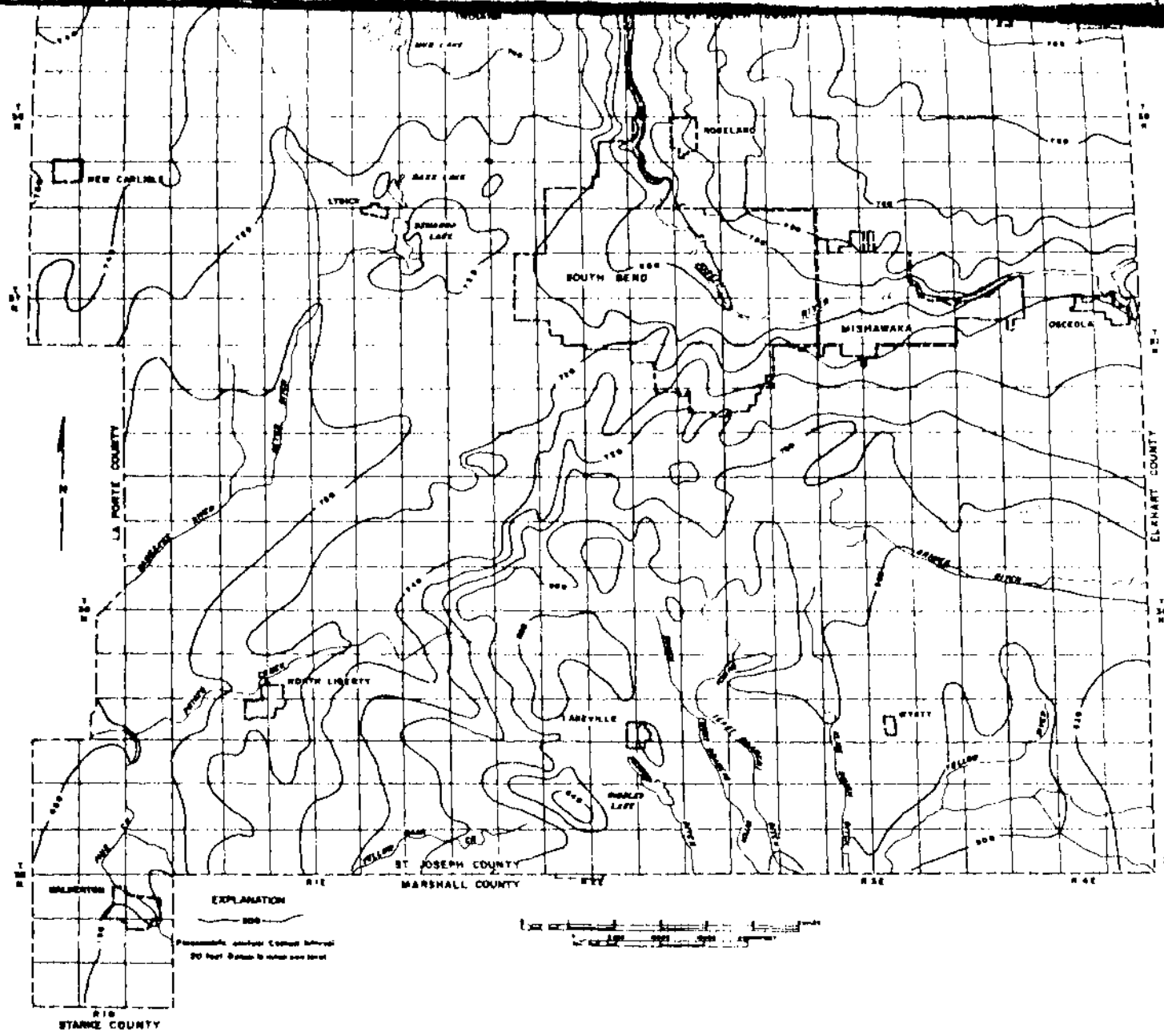


FIGURE 5 — MAP SHOWING CONFIGURATION OF THE PIEZOMETRIC SURFACE OF UNIT 3, ST JOSEPH COUNTY, JANUARY 1960

Unit 2

Water-Bearing Characteristics

Unit 2 consists chiefly of silt till, which mantles much of unit 3. The rate of recharge to the underlying aquifer depends in part on the vertical permeability of unit 2. Rosenshein (1963, p. 16) estimated that the vertical permeability of the unit averages 0.007 gpd per square foot in Lake County. Although no calculations have been made for St. Joseph County, the till in this area is much coarser grained and the vertical permeability is probably 1.5 to 3 times that of unit 2 in Lake County.

The porosity of the unit may be about 40 percent and its saturated thickness may average 20 feet. On the basis of these estimates, the unit may have as much as 2 million acre-feet of water in storage. However, because of its small permeability, direct production from the unit is limited to relatively thin, discontinuous sand and gravel zones which are used only for domestic and farm supplies.

Hydrologic Aspects

Unit 2 is the second most extensive unit exposed at the surface in St. Joseph County. The flow of many streams and ditches is determined to a significant extent by its ground-water discharge and runoff characteristics. Although this discharge has not been calculated, it is considerably less than that estimated by Rosenshein and Hunn (1968a, p. 29) for the unit in Lake County (110 mgd), where the unit covers three-fourths of the land surface.

SUMMARY

The principal sources of ground water in St. Joseph County are the unconsolidated rocks of Quaternary age. The underlying bedrock is not used; however, it is a potential source of water of uncertain quality and quantity. The unconsolidated rocks form a single but complex hydrologic system composed of three units. This system has a potential yield from natural recharge of about 400 mgd (million gallons per day), of which about 54 mgd or about 13 percent is currently being withdrawn.

Geohydrology of rock units.--Unit 4, a clay till, contains discontinuous zones of sand and gravel that are used locally for industrial and municipal supplies. The permeability of these zones ranges from less than 100 to about 800 gpd per square foot. Vertical permeability of the unit is probably about 0.003 gpd per square foot. The unit may have as much as 6 million acre-feet of water in storage.

Sand and gravel within unit 4 is the principal aquifer of the South Bend-Mishawaka area. The transmissibility of this zone ranges from less than 10,000 to more than 300,000 gpd per foot. The permeability ranges

from less than 200 to more than 6,000 gpd per square foot. The coefficient of storage is about 0.0003.

Unit 3, a sand and gravel, is the principal aquifer underlying the county. Its coefficient of transmissibility ranges from less than 10,000 up to 500,000 gpd per foot. The unit has an estimated regional transmissibility of 70,000 gpd per foot. The regional values of the coefficient of storage are probably about 0.003 for the artesian part and 0.12 for the water-table part. Recharge to the artesian part and to much of the water-table part must percolate through the overlying till (unit 2). This recharge is about 40 mgd. Extensive development of the artesian part will increase its potential to about 80 mgd. Direct recharge to the water-table part is about 1.2 mgd per square mile, and the estimated potential yield is 300 mgd.

The principal dissolved constituents in the water from unit 3 are calcium, magnesium, and bicarbonate. The concentration of dissolved solids averages about 340 ppm.

Unit 2, a silt till, is the confining layer for the artesian part of the principal aquifer. Its vertical permeability is probably greater than 0.007 gpd per square foot. The unit may have as much as 2 million acre-feet of water in storage. Discontinuous sand and gravel zones within the unit are used occasionally for domestic and farm supplies. It is the second most extensive unit exposed at the surface in the county. The flow of many streams and ditches is influenced by the ground-water discharge and runoff characteristics of the unit.

GLOSSARY

Hydraulic Coefficients (after Ferris and others, 1962)

Permeability.--Measure of a material's capacity to transmit water; expressed as rate of flow of water in gallons per day through a cross-sectional area of 1 square foot under a hydraulic gradient of 1 foot per foot at prevailing water temperature.

Storage.--Volume of water released from or taken into storage per unit surface area of the aquifer per unit change in the component of head normal to that surface.

Transmissibility.--Rate of flow of water, at the prevailing water temperature, in gallons per day, through a vertical strip of the aquifer 1 foot wide extending the full saturated height of the aquifer under a hydraulic gradient of 1 foot per foot.

Miscellaneous Terms

Effluent seepage.--Discharge of ground water to surface bodies of water.

Porosity.--Volume of pore space expressed as a percentage of the total volume of the rock.

Specific capacity.--Yield of a well in gallons per minute per foot of drawdown.

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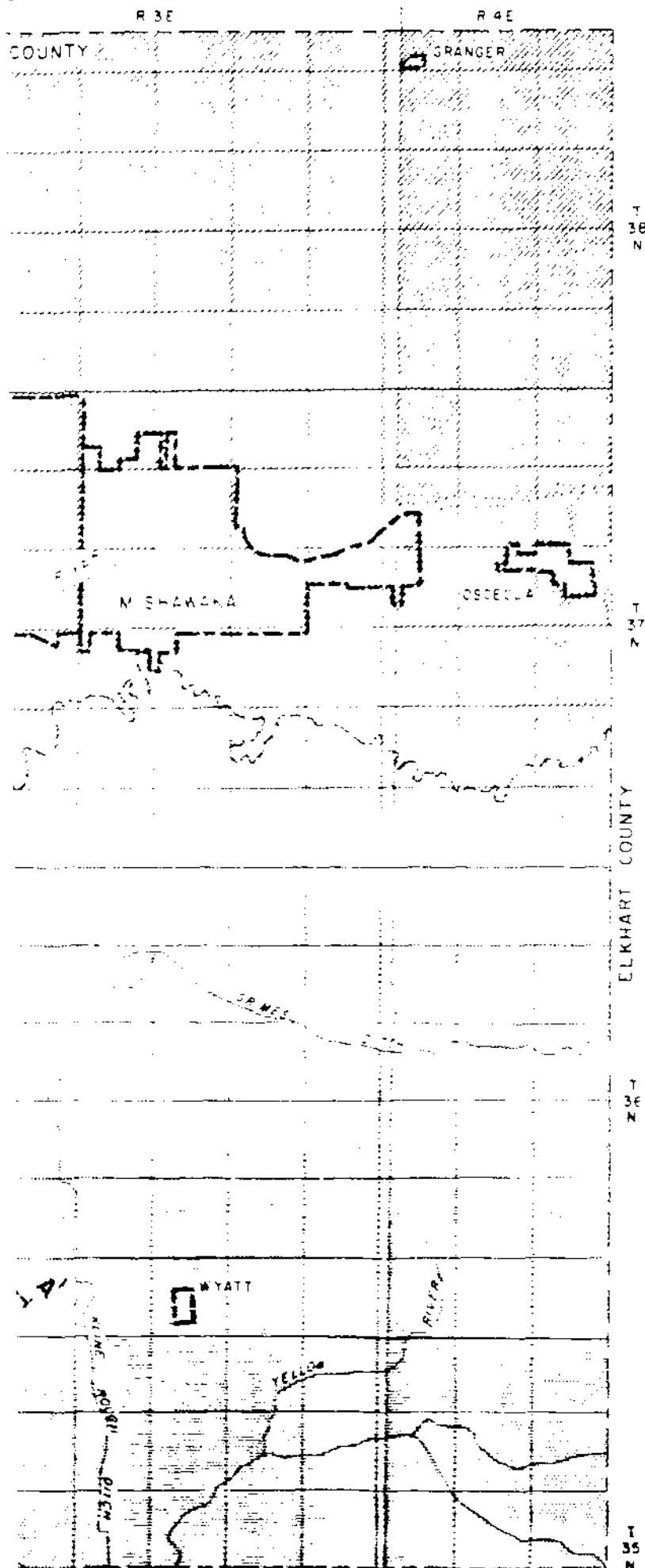
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EXPLANATION

UNIT 2

TILL



Silt, clayey and sandy, pebbly and cobbly, generally buff to tan or reddish-brown in outcrop. Forms dissected ground and terraced moraines.



Silt, clayey and sandy, pebbly and cobbly, generally tan to brown in outcrop. Forms Mackinac Moraine and associated ground moraine.

UNIT 3

CHIEFLY GLACIOFLUVIAL



Sand, med. to coarse, somewhat pebbly, silt, and clayey, and sand and gravel. Locally interbedded with layers of argillaceous silt and clay of relatively small area extent. Contains some wind-blown sand.

UNIT 4

TILL



Clay, locally hard and compact, gray. Contains some layers of sand and gravel. (Shown on cross section only.)

BEDROCK



Chiefly shale and limestone. (Shown on cross section only.)

PLISTOCENE TO RECENT

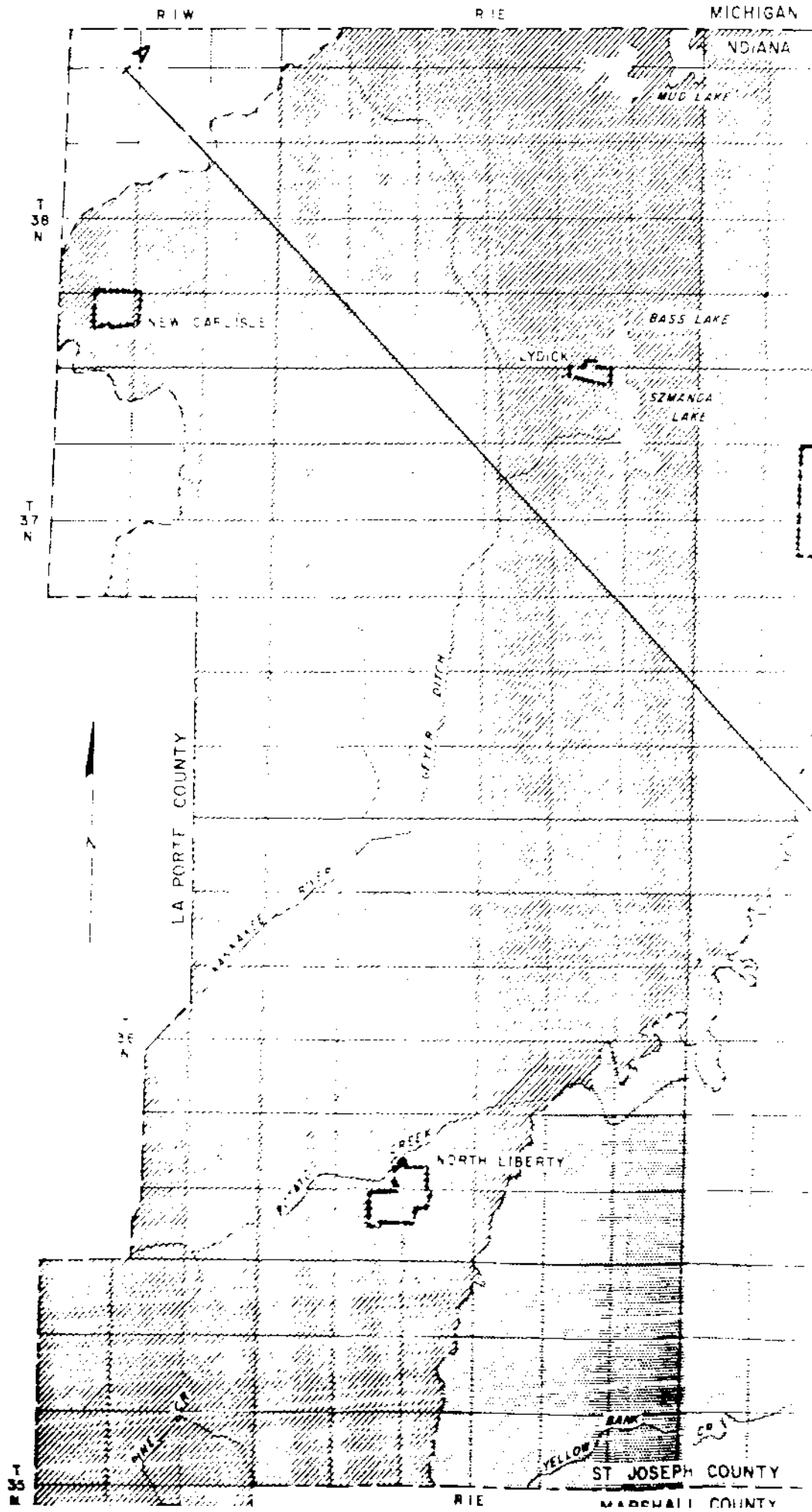
PRE-PLISTOCENE

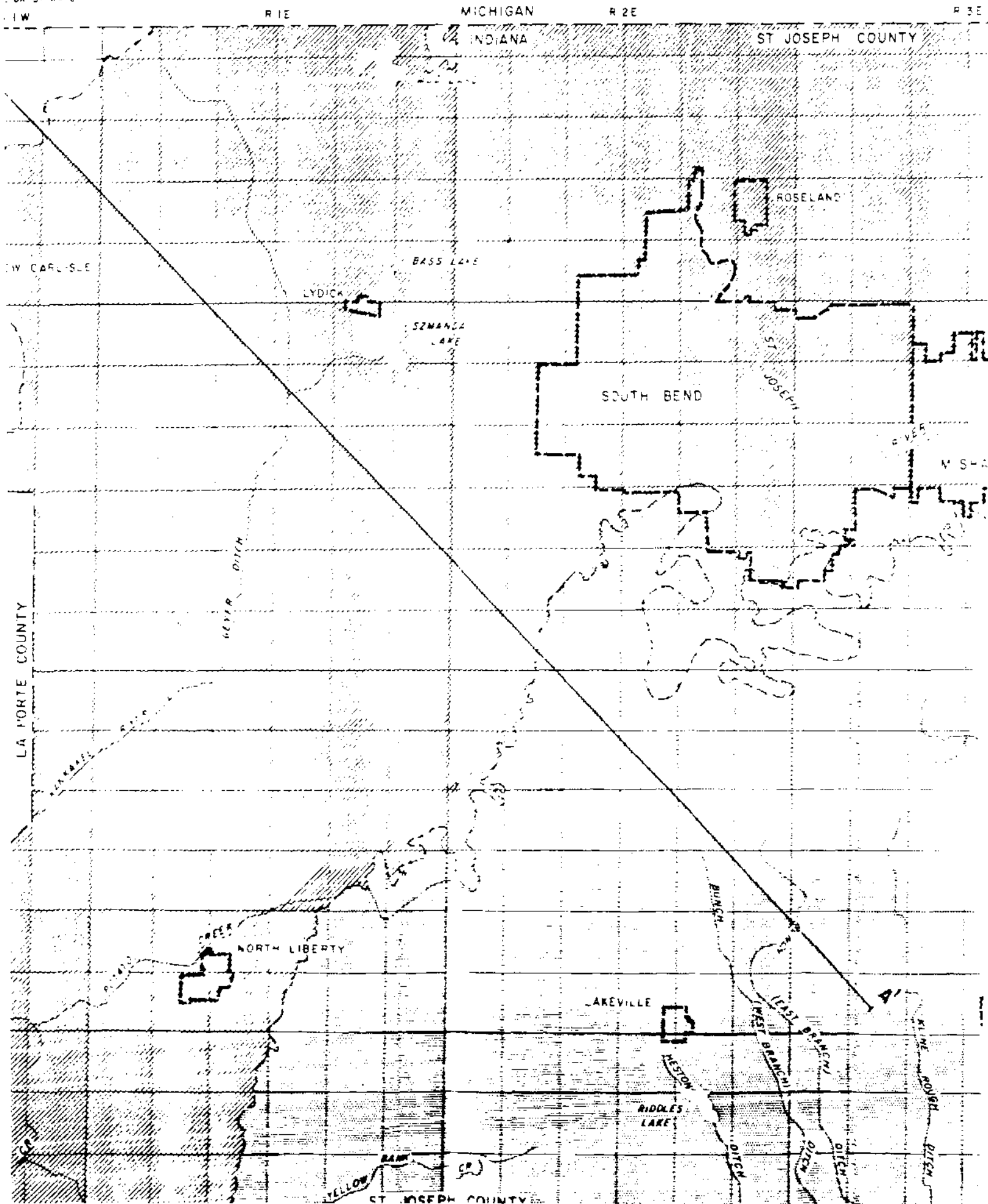
QUATERNARY

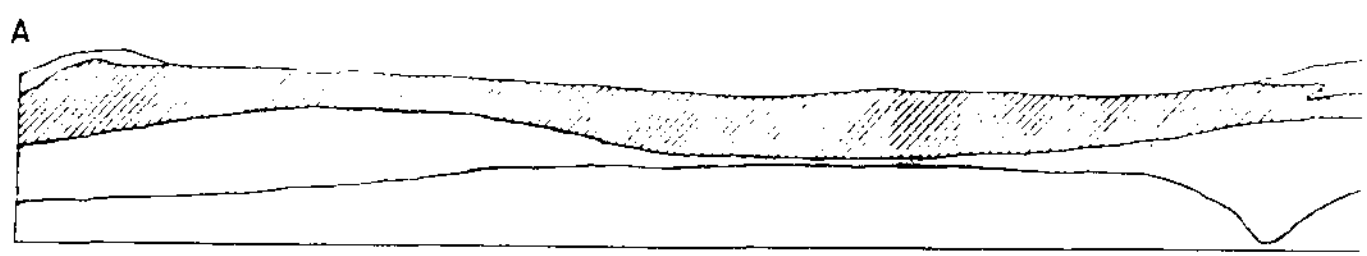
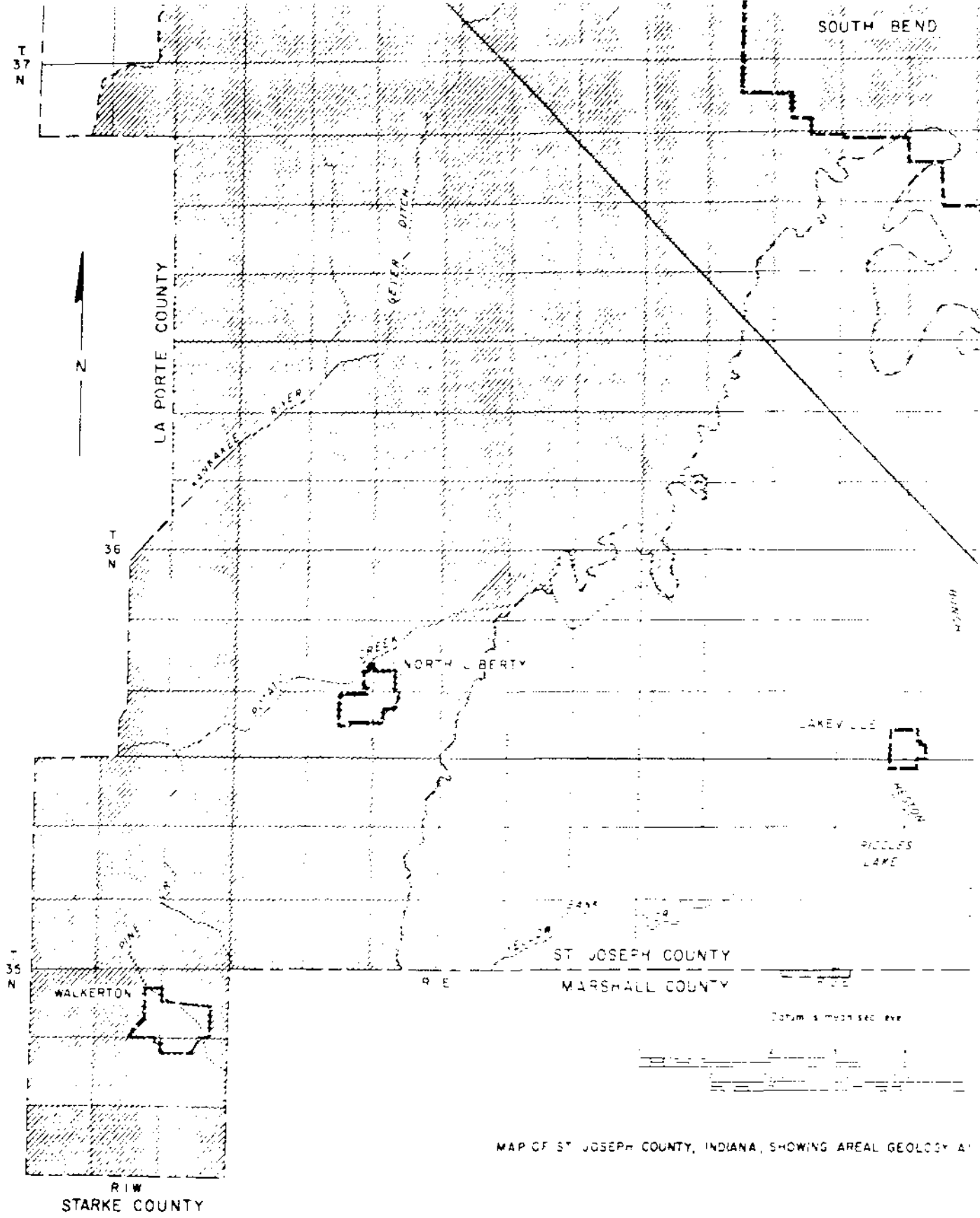
UNDIFFERENTIATED

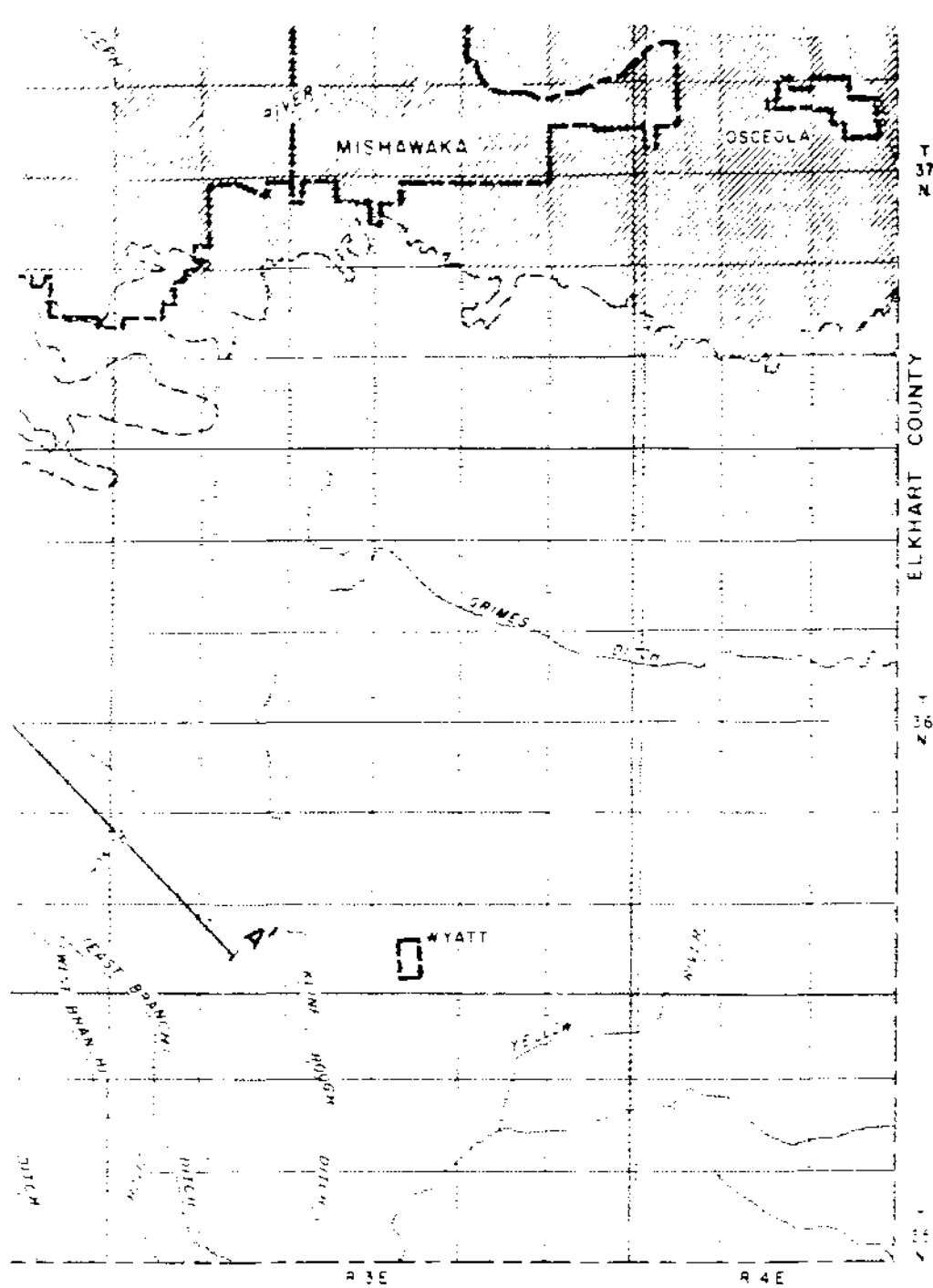
Boundaries of unit 2 generalized in part from an interpretation of a U. S. Department of Agriculture soil map (1930) and others, 1950, by A. F. Schneider, and the Geological Survey.

STATE OF INDIANA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATER









PL

silty, and clayey, and sand and gravel
Locally interbedded with layers of
organically rich silt and clay of
relatively small gravel at base
some wind-blown sand

UNIT 4
TILL



Clay, locally hard and compact, gray
Contains some layers of sand and gravel
(Shown on cross section only)

PRE-PLEISTOCENE

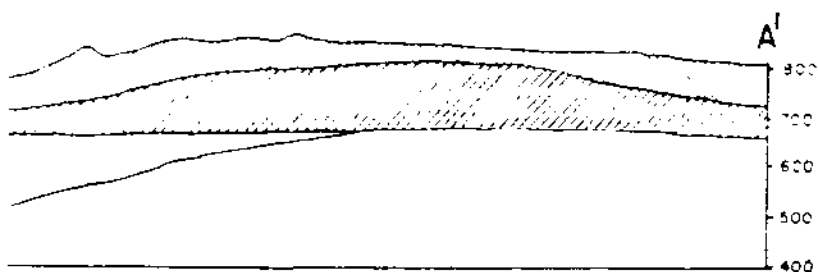
BEDROCK



Chiefly shale and limestone
(Shown on cross section only)

Boundaries of unit 2 generalized in part
from an interpretation of a U.S.
Department of Agriculture soil map
Ulrich and others, 1950 by A.E. Schneider,
Indiana Geological Survey

IND. GENERALIZED CROSS SECTION





WATER-TABLE DATA



Estimated transmissibility generic range from 10,000 to 25,000 gpc/d. Specific capacities of wells estimated to range from 5 to 10 gpm per foot of drawdown. Possible source of water for users requiring 25 to 100 gpm.



Estimated transmissibilities generally range from 25,000 to 50,000 gpd ft. Specific capacities of wells estimated to range from 10 to 20 gpm per foot of drawdown. Possible source of water for users requiring 180 to 800 gpm.



Estimated transmissivities generally range from 50,000 to 100,000 gpd/ft. Specific capacities of wells estimated to range from 20 to 40 gpm per foot of drawdown. Possible source of water for users requiring 800 to 3,000 gpm.



Estimated transfer rates for generic storage from 100,000 to 500,000 gal. to specific capacities of wells estimated to be more than 40 gpm. per foot of drawdown. Possible source of water for users from 10,000 to more than 3,000 gpm.

APTES LA PAGE



Estimated treatment rates for general population from 10,000 to 25,000 gpd per specific capacities of wells estimated to range from 7 to 15 gpd per foot of drawdown. Possible source of water for users requiring 120 to 300 gpd.



Estimated transmissibilities generally range from 25,000 to 50,000 gpd/ft. Specific capacity of wells estimated to range from 15 to 25 gpd/ft. for drawdowns. Potential source of water for wells requiring 300 to more than 1,000 gpm.

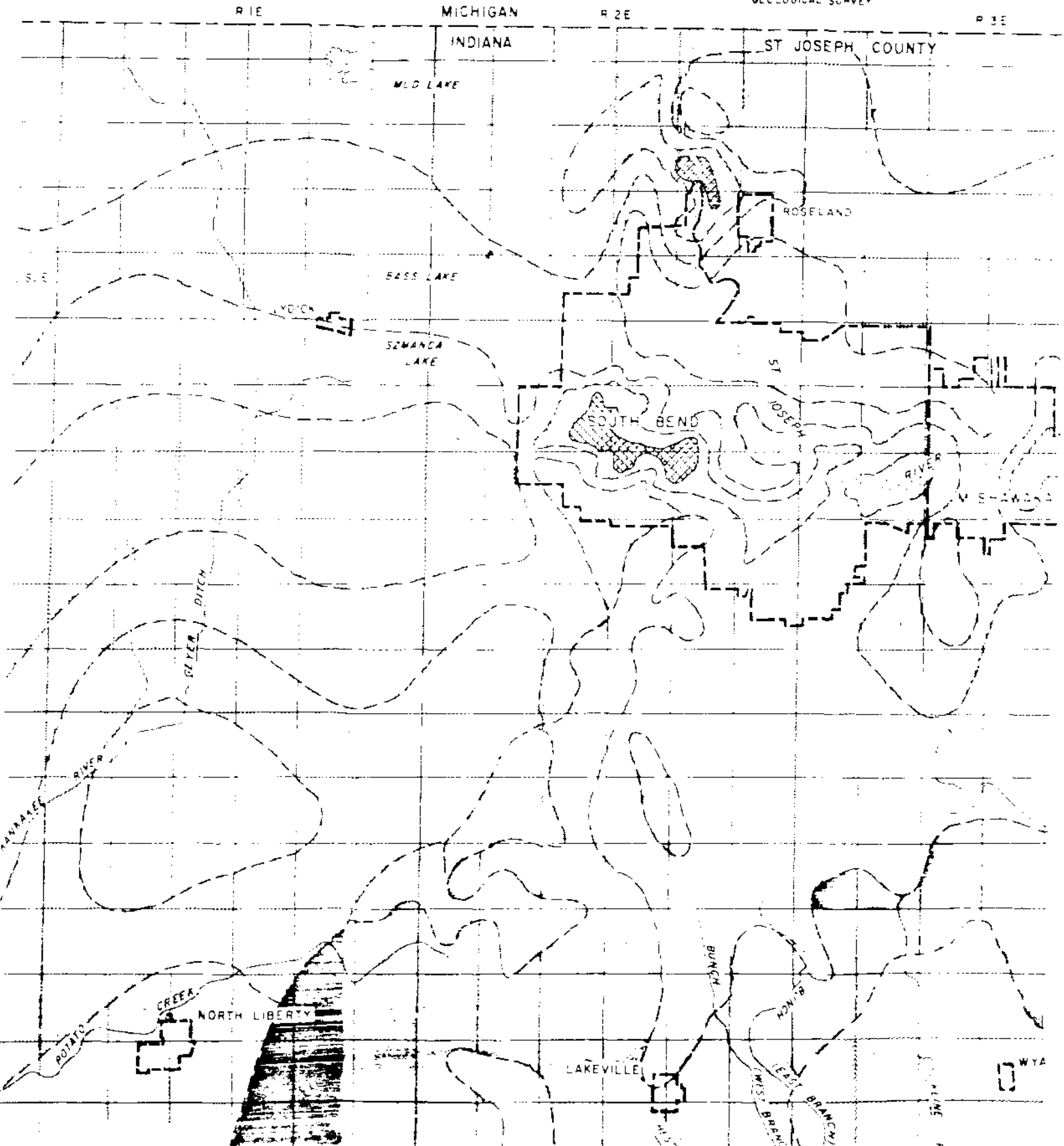
APPROXIMATE BOUNDARY



What? Is interactivity considered also part of...

RESOURCES

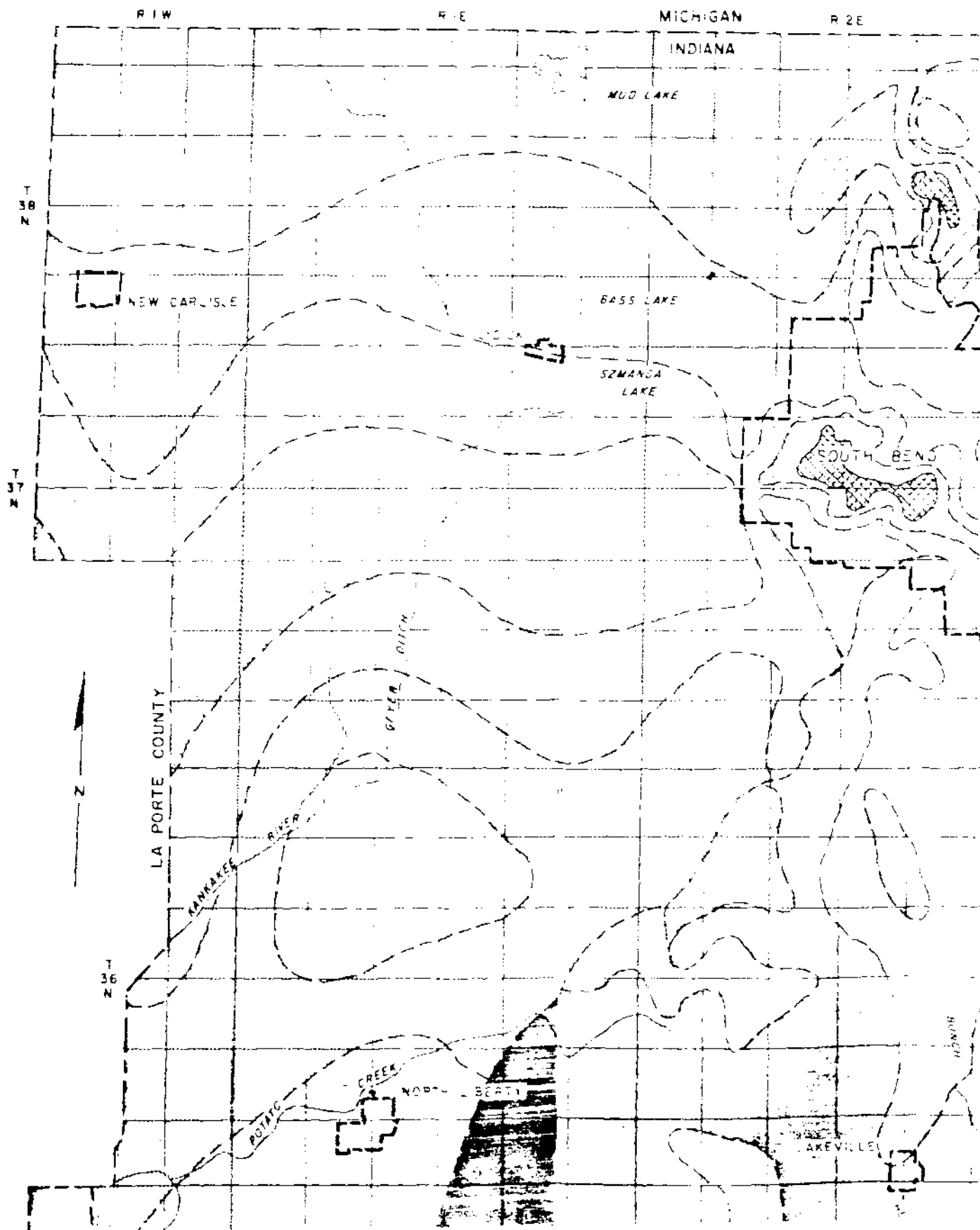
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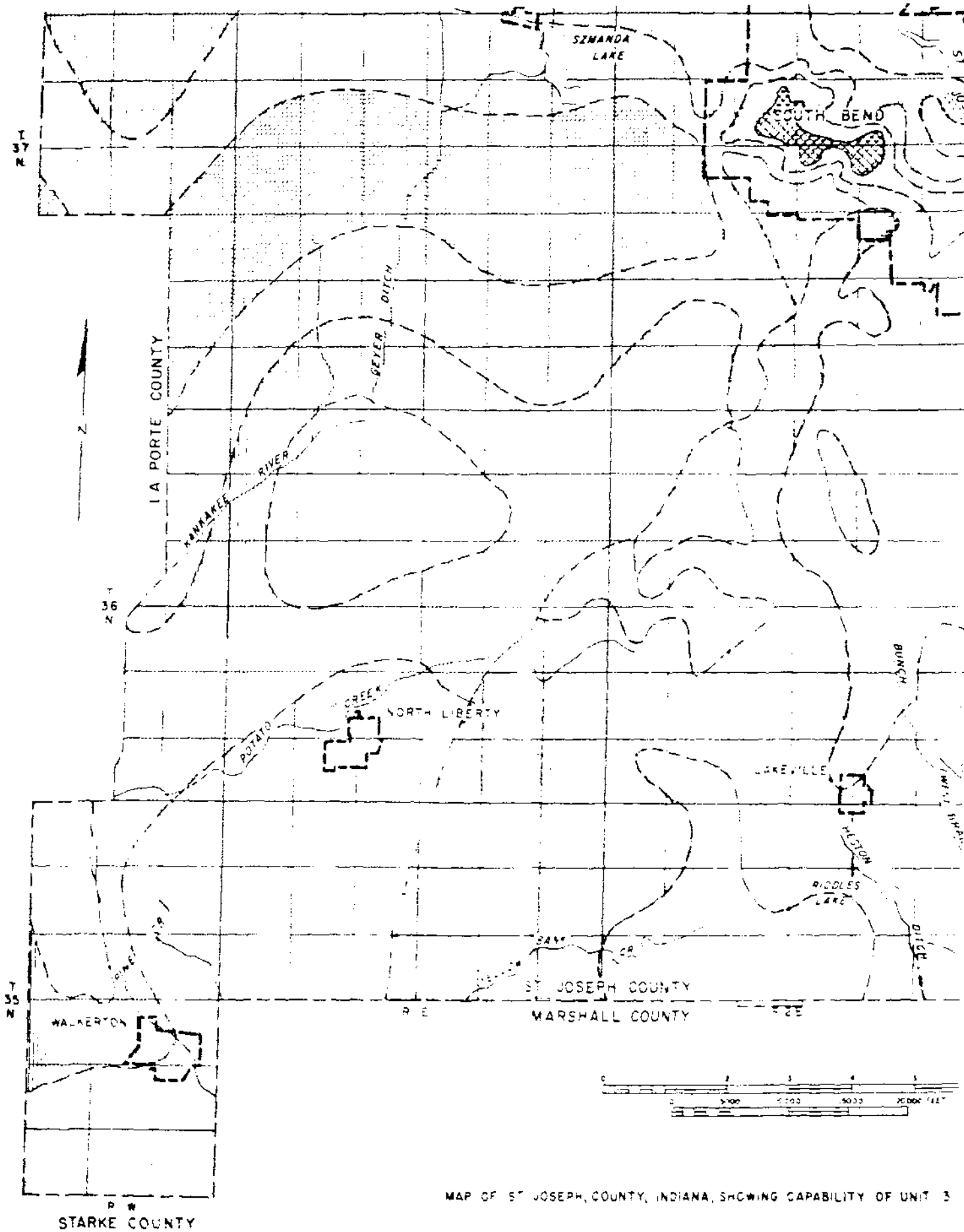


WYA

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DIVISION OF WATER

UNITED STATES





MAP OF ST JOSEPH COUNTY, INDIANA, SHOWING CAPABILITY OF UNIT 3

800 gpm

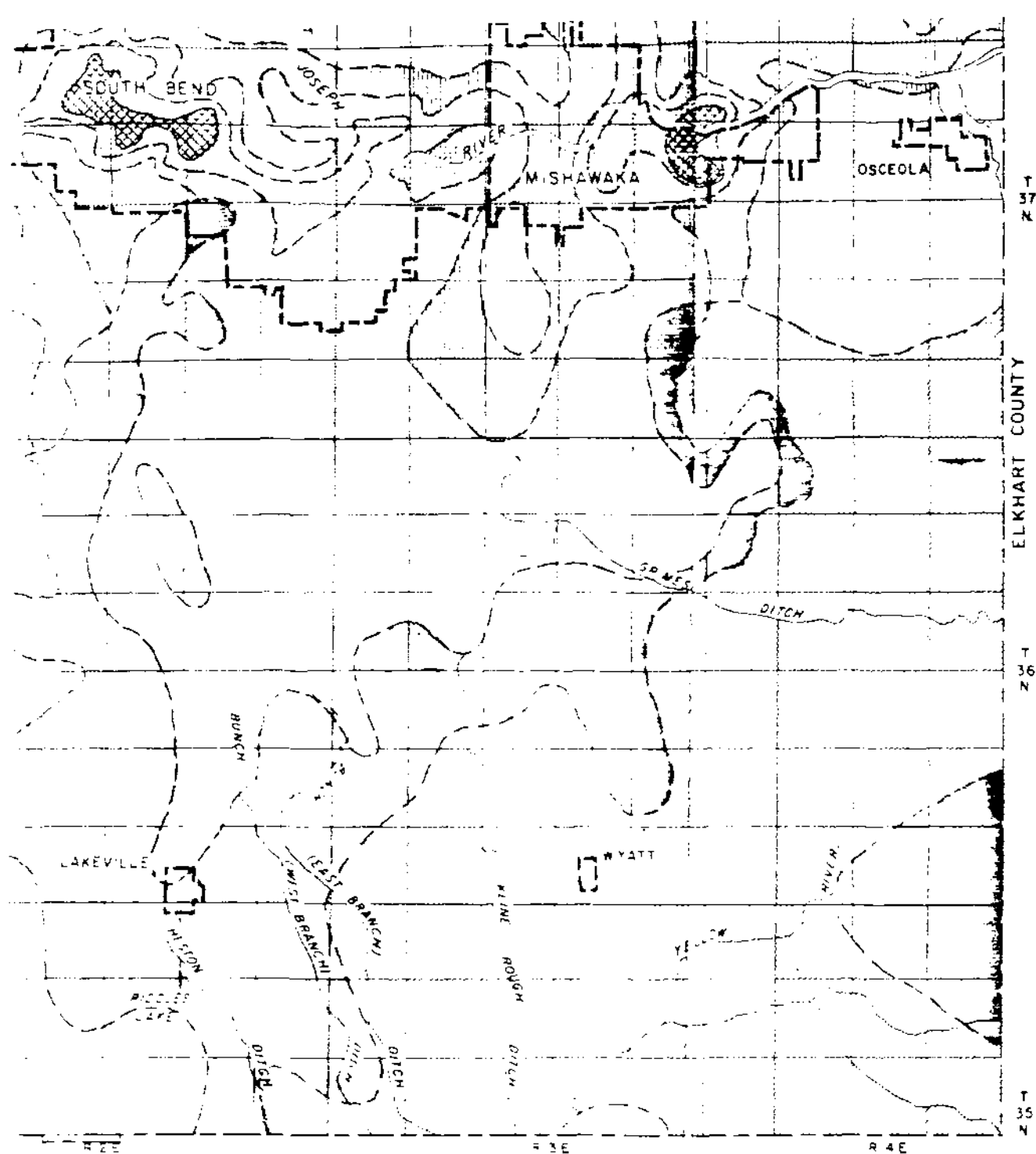
Estimated flow
from 40 g
capacities
20 to 40 g
source of
3,000 gpm

Estimated flow
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Estimated flow
from 10 g
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7 to 5 g
source of
500 gpm

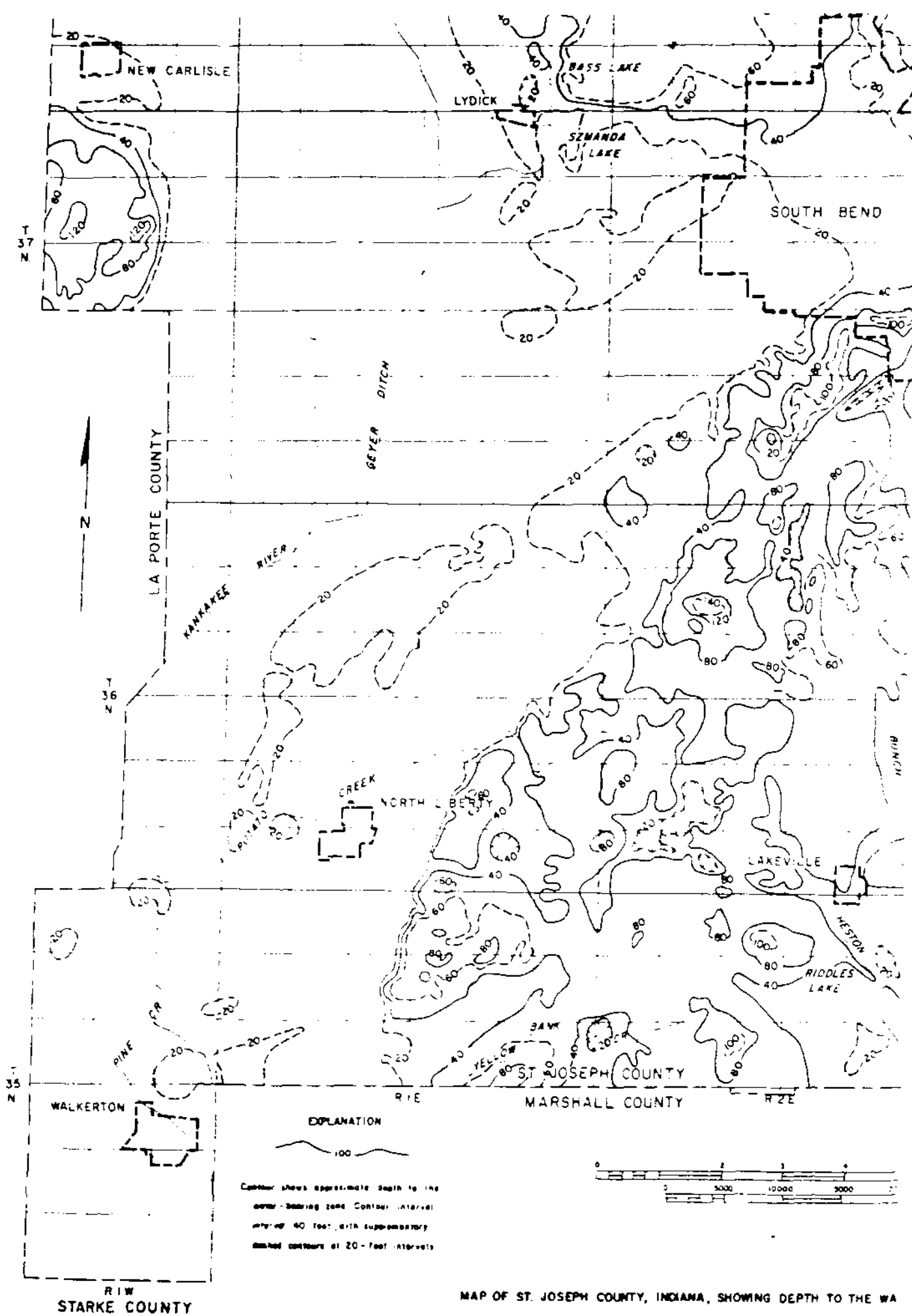
Estimated flow
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Estimated flow

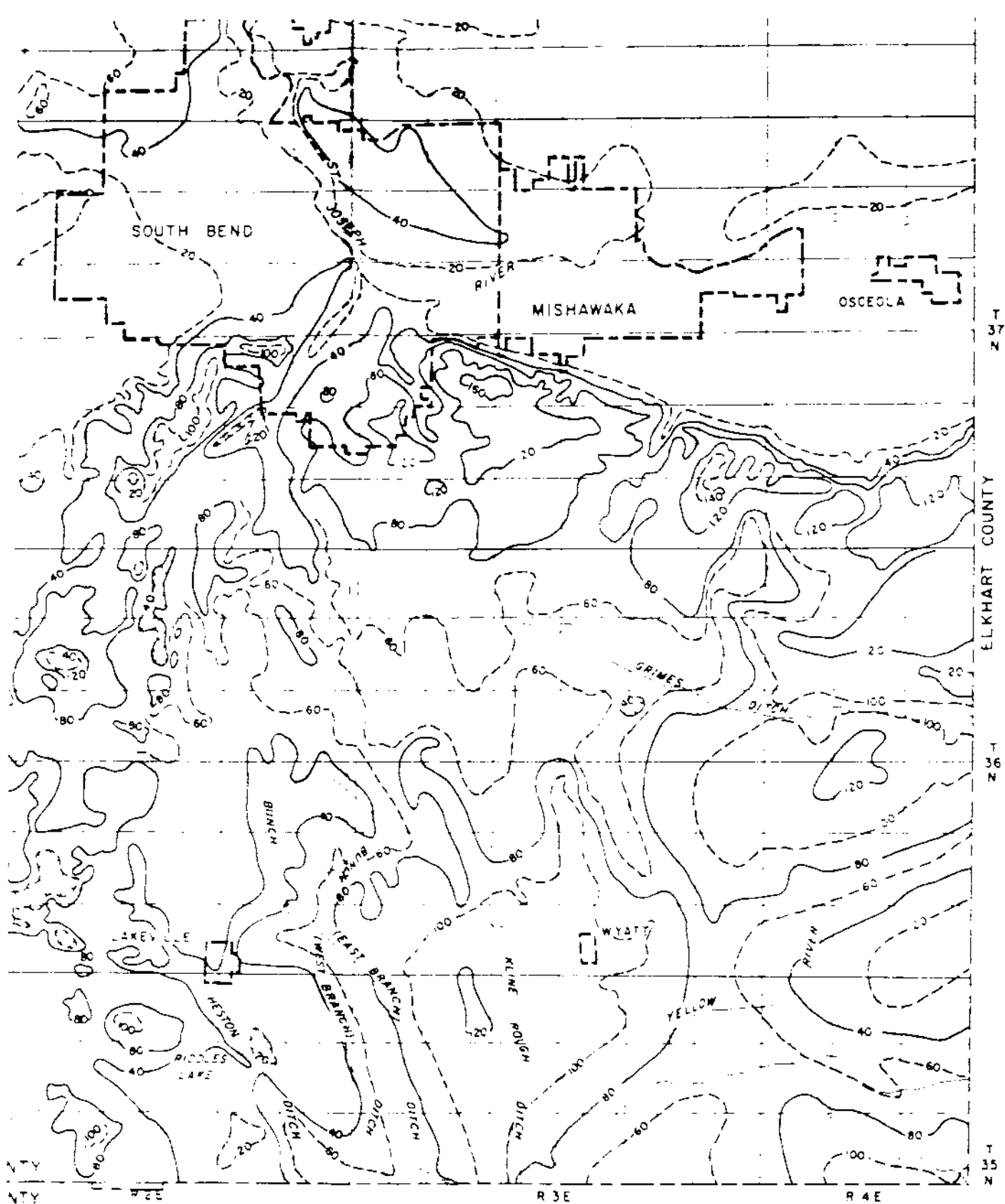


Base from U.S. Topog. 1:250,000
Topographic map

SHOWING CAPABILITY OF UNIT 3 AS SOURCE OF WATER



MAP OF ST. JOSEPH COUNTY, INDIANA, SHOWING DEPTH TO THE WA



Base from U.S. Geological Survey
topographic maps



INDIANA, SHOWING DEPTH TO THE WATER-BEARING ZONE IN UNIT 3

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BULLETIN 33 PLATE 3

GAN

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R 4 E

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ST JOSEPH COUNTY

GRANGER

ROSELAND

SOUTH BEND

M SHAWANA

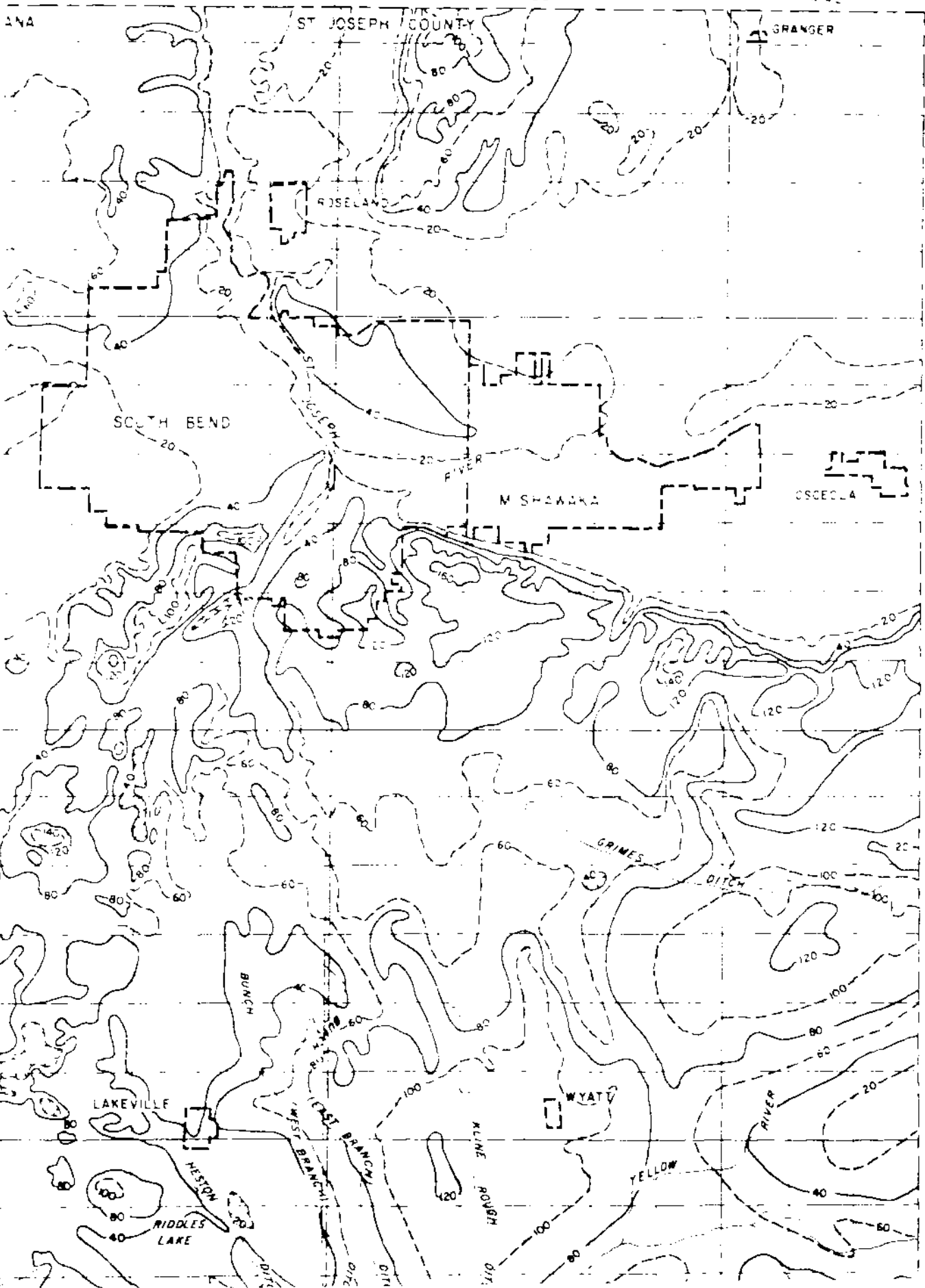
OSCEOLA

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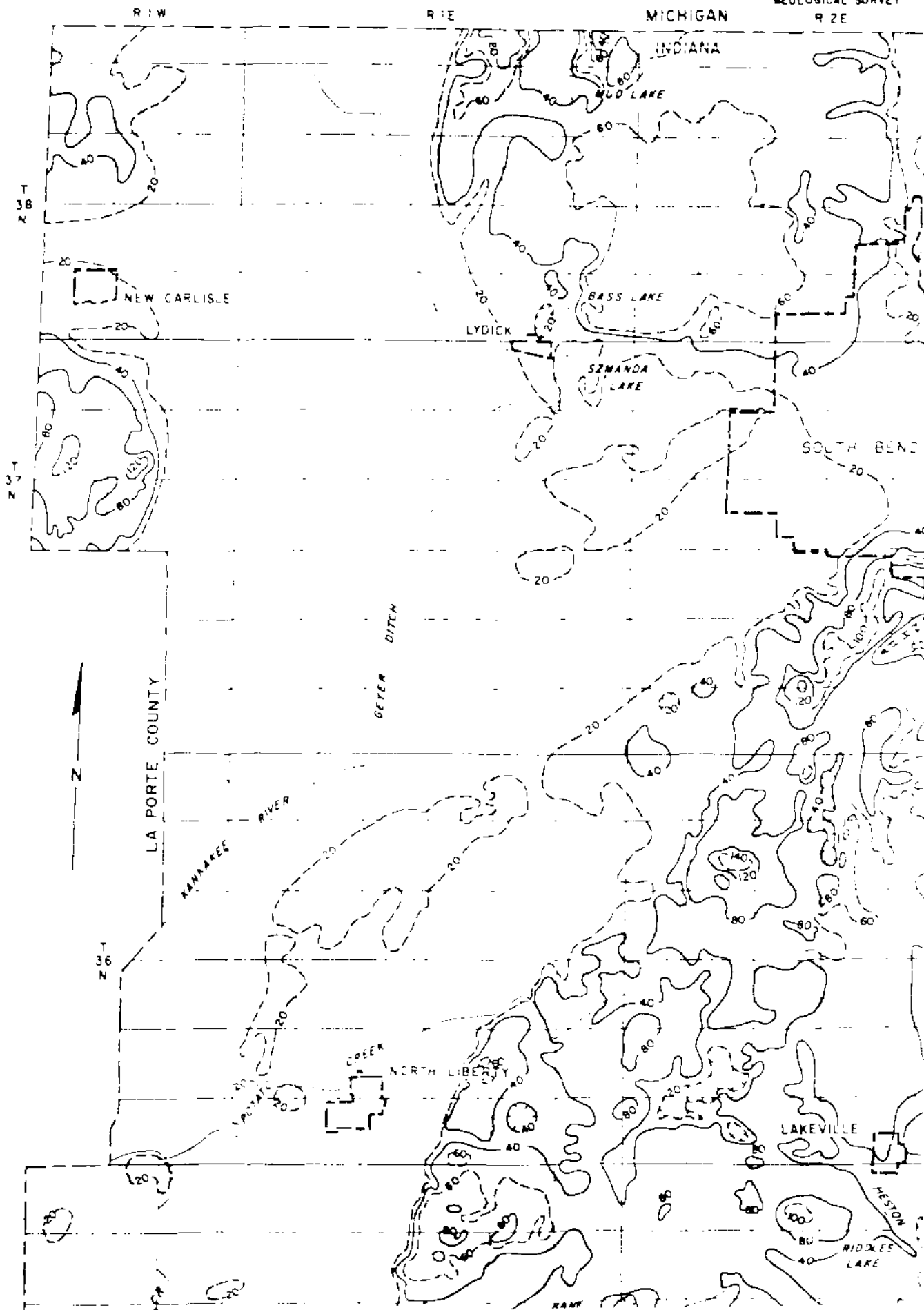
ELKHART COUNTY

T 36 N



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STATE OF INDIANA

INDIANA DEPARTMENT OF CONSERVATION

DIVISION OF WATER RESOURCES

BULLETIN NO. 15

**GROUND-WATER RESOURCES
OF NORTHWESTERN INDIANA**

Preliminary Report: St. Joseph County



Prepared by the

GEOLOGICAL SURVEY

UNITED STATES DEPARTMENT OF THE INTERIOR

In cooperation with the

DIVISION OF WATER RESOURCES

INDIANA DEPARTMENT OF CONSERVATION

INDIANA DEPARTMENT OF CONSERVATION

Donald E. Foltz, Director

BULLETIN NO. 15

OF THE

DIVISION OF WATER RESOURCES

Charles H. Bechert, Director

GROUND-WATER RESOURCES OF NORTHWESTERN INDIANA

Preliminary Report: St. Joseph County

BY

J. S. Rosenshein and J. D. Hunn

GEOLOGISTS, U. S. GEOLOGICAL SURVEY

Prepared by the

GEOLOGICAL SURVEY

UNITED STATES DEPARTMENT OF THE INTERIOR

In cooperation with the

DIVISION ON WATER RESOURCES

INDIANA DEPARTMENT OF CONSERVATION

1962

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the factors affecting the water levels in the aquifer were due chiefly to natural causes.

GENERAL GEOLOGY AND SOURCES OF GROUND WATER

The oldest known consolidated rocks underlying St. Joseph County are of Ordovician age. These rocks consist of dolomite, dolomitic limestone, and shale and are overlain by dolomitic limestone, shale, and dolomite of Silurian age. The rocks of Ordovician and Silurian age are not used as a source of water supply in the county because of their depth and the highly mineralized water which they contain.

The rocks of Silurian age are overlain by dolomite and dolomitic limestone of Middle Devonian age. These rocks underlie blue-black bituminous shale of Devonian age (Logan, 1932) or Devonian and Mississippian age (Patton, 1956). This shale is listed as Devonian age in table 3. The rocks of Devonian and Mississippian(?) age grade upward into shale of Mississippian age which is overlain locally by thin limestone. Although these limestones and shales of Devonian and Mississippian age are not used as a source of water in St. Joseph County, they are a potential source of water, and the quality and quantity available are uncertain.

The bedrock is overlain by unconsolidated glacial drift of Pleistocene age. The drift forms several prominent topographic features in the county (Klaer and Stallman, 1948, pl. 2; Leverett and Taylor, 1915, pl. 6; Wayne, 1958) such as the Valparaiso moraine in the extreme northwestern part, a two-prong extension of the Kalamazoo moraine in the north-central part; the Maxinkuckee moraine in the south-central part, and glaciofluvial plains and terraces in the northern and southwestern parts.

The unconsolidated rocks of Pleistocene age range in thickness from less than 50 feet to about 300 feet. The rocks consist chiefly of glaciofluvial sand and gravel, clayey till, and some glaciolacustrine clay and silt. The glaciofluvial sand and gravel is locally more than 200 feet thick and is the chief source of ground water for domestic and stock, industrial, and public supplies. Wells that tap this aquifer are generally less than 200 feet deep and yield from 5 to more than 2,000 gpm.

The unconsolidated rocks of Pleistocene age are overlain locally by thin alluvium, eolian sand, and organically rich sand, silt, and clay of Recent age. The deposits of Recent age are too thin to be a source of ground water.

Plate 2 shows the availability of ground water in the unconsolidated rocks underlying the county. In addition, plates 3 and 4 show respectively the areal distribution of hardness and iron content of water from sand and gravel of Pleistocene age. The water is hard to very hard. The hardness is generally greater than 200 ppm and less than 500 ppm. However, in several small areas in the northern and southern parts of the county the hardness is less than 200 ppm. Although the iron content in much of the county exceeds maximum concentration

recommended in the U. S. Public Health Service drinking-water standards (p.252) for iron and manganese together, there are sizeable areas where this standard is not exceeded.

CONFINED AND UNCONFINED CONDITIONS

Ground water occurs in the consolidated and unconsolidated rocks of St. Joseph County under confined (artesian) conditions or under unconfined (water-table) conditions. Under confined conditions the saturated water-bearing material is overlain directly by relatively impervious material, and the water will rise above the level at which it is encountered in the water-bearing material. Under unconfined conditions the water-bearing material is overlain directly by permeable unsaturated material, and the water will not rise above the level at which it is encountered.

TYPES OF WELLS

Drilled, driven, and jetted wells are the principal types of water wells used in St. Joseph County. Most water wells 3-inches or more in diameter are constructed by the cable-tool, or percussion, method, but a few wells have been drilled by the rotary and reverse-rotary methods. When the water-bearing material is sand and gravel, the well is generally finished with a well screen set in the aquifer below the bottom of the well casing. (See Rosenst and Cosner, 1956, p. 6, for a detailed description of a well screen.) A modification of this type of well, the gravel-packed well, has a gravel lining inserted between the well screens and the water-bearing material.

Water wells less than 3-inches in diameter are constructed in unconsolidated material by driving or jetting. The driven well consists of a small-diameter pipe having a drive point attached to the end, which is driven into shallow water-bearing material. The jetted well is constructed by forcing water under pressure out of a hollow-rod or small-diameter drill pipe that is fitted with a jetting bit. As the material is washed out of the hole ahead of the casing, the casing is driven down into the hole. After the water-bearing material is penetrated the well is generally finished with a well-point screen set in the water-bearing material below the bottom of the casing. Table 1 relates the grain-size in inches and millimeters to the slot and the gauze size of screens commonly used in water wells.

Oil or gas test holes in St. Joseph County generally were drilled by the cable-tool method. Structure test holes for foundations and bridges generally are drilled by the wash-boring method. In this method test hole samples usually are collected by driving a sampling tube into the material after specific intervals of boring.

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Table 1.--Grain size and equivalent screen openings

Grain size: After Wentworth (1922).
Equivalent screen openings: From
commercial catalogs for
water-well supplies.

Slot size: In thousandths(0.001)
of an inch.
Gauze size: Number of wire strands
per lineal inch.

Material	Grain size		Equivalent screen opening	
	Inches	Millimeters	Slot size	Gauze size
Gravel-----	>0.08	>2	>80	-----
Very coarse sand-	.04 - .08	1 - 2	40 - 80	<20
Coarse sand-----	.02 - .04	.50 - 1	20 - 40	40 - 20
Medium sand-----	.01 - .02	.25 - .50	10 - 20	60 - 40
Fine sand-----	.005 - .01	.125 - .25	6 - 10	90 - 60
Very fine sand---	.002 - .005	.062 - .125	-----	-----
Silt-----	.00015 - .002	.004 - .062	-----	-----
Clay-----	<.00015	<.004	-----	-----

SUMMARY

Preliminary evaluation of the basic data shows that adequate quantities of ground water are available for domestic, stock, public, and industrial supplies from sand and gravel of Pleistocene age. The underlying bedrock is not used as a source of water. However, the rocks of Devonian and Devonian and Mississippian(?) age are a potential source of water of uncertain quality and quantity.

The quality of water from the rocks of Pleistocene age varies. The water is generally hard to very hard. In several small areas in the northern and southwestern parts the hardness of water is less than 200 ppm. Although the iron content exceeds the U. S. Public Health Service drinking-water standards for iron and manganese together in much of the county, there are sizeable areas in which the iron content does not exceed these standards.

RECORDS

The records of about 1,850 wells and test holes are given in table 2. The table contains information about well construction, water levels, yields and drawdowns, conditions of occurrence, thickness and characteristics of water-bearing materials, type of pump, and other data. The altitude of the land surface at all wells, except test borings was interpolated from topographic maps or extrapolated from aerial photographs using the vertical control of the Topographic Division of the Geological Survey. Altitudes of borings were leveled by the Federal or State agency for whom the borings were made.

Table 3 contains the selected logs of about 710 wells and test holes. This table gives the driller's description of the material encountered, pertinent remarks with regard to the material, and the authors' interpretation of the geologic age of the material.

EIGHTEEN PAGES REDACTED

Exemption 9,

5 U.S.C. §552(b)(9)

Geological and geophysical information and data, including maps, concerning wells.